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THE DISTRIBUTION OF MUSCULAR ACTION POTENTIALS DURING IMAGING

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THE DISTRIBUTION OF MUSCULAR ACTION POTENTIALS DURING IMAGING*[1]

William A. Shaw

1. PRESENT PROBLEM

Through the use of levers, tambours, carbon paper and other pressure devices, the fact that muscular actiyity accompanies such processes as silent reading, mental arithmetic, imagining, recollecting, problem solving and the like has been fairly well established. No longer satisfied with showing merely that muscular activity accompanies the processes just mentioned, we have selected one of them, imaging, and have attempted to study the distribution of such activity to find out (1) whether, during such activity, the striped muscles are generally active in the various parts of the body; (2) whether there is any tendency toward localization in the muscle groups commonly thought to be involved in the performance of such acts; (3) and the probable significance of this distribution.

2. PREVIOUS BASIC STUDIES

Freeman (5-6) in his study of the "spread of neuromuscular activity" found by the use of levers that concomitant with the flexion of the fingers of the right hand there was an increase in the tension of the quadriceps of both arms. Such tension was highly variable during mental arithmetic and with some training there was evidence of it becoming localized in the muscle groups involved.

Jacobson (8-14) made several studies of imagination, recollection, and inner speech and reported that during imagination of specific acts there was an increase in the amplitude of the action potentials obtained from the muscles involved. There was evidence of such increase being confined to the specific muscle groups. This is in partial agreement with Freeman. Furthermore, when the subjects were instructed to relax and to keep relaxed during the time they were to engage in imaging, Jacobson found that they could not imagine.

Clites (2) reported that subjects who are successful in solving problems have an increase in action potentials from

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[1] This paper has been rewritten from a master's thesis on file at the Indiana University Library.

the right arm. Movement became less, and tensions in the right hand, which rested on a tambour, decreased although, as he pointed out, such decreases may have been due to a stiffening of the fingers. He reported, also, that unsuccessful subjects when compared with successful subjects showed fewer action potentials during the time they attempted to solve a problem, that there was less overt movement in the muscles of the forearm, but that grip tension remained the same.

Golla and Antonovitch (7), Lombard (16), Bills (1), Jones (15) and others have found that tensions accompany such mental processes as silent reading, mental arithmetic, attending to certain kinds of music, learning nonsense syllables, tone and color discrimination, etc.

3. MUSCULAR ACTION POTENTIALS DURING OVERT MOVEMENT

Part I. Apparatus, technique and procedure:

Something with which to compare the distribution of action potentials taken during imaging of certain acts was deemed necessary. A small group of subjects was given a hand dynamometer to squeeze and action potentials were taken from several parts of the body. The cathode ray oscillograph and amplifier used to secure these action potentials has been described in a publication by R. C. Davis (3).

The subjects used were undergraduate men and women. Each one was seated in a cage shielded against electrical disturbances from the laboratory. The active electrode consisting of a disc of iron one-quarter inch in diameter centered in a square inch of bakelite was placed on the upper right arm and the right foot immersed in a physiological saline solution which acted as the inactive electrode. The subjects were instructed to relax, and were given the following instructions: "At the signal 'Squeeze!' you are to close your left hand without lifting it from the arm of the chair and to squeeze as hard as you can. At the signal 'Relax!' you are to stop squeezing and to relax." Two photographs of relaxation, two of tension, and one of after-tension were secured.

There were 12 subjects used, although not all were used in testing every muscle group. Action potentials were taken from the right and left upper and lower arms and from the hand; from the upper and lower legs and the foot; and from the jaw, tongue, nose, ears, back of neck, and chest.

In measuring the film the heart-beats were eliminated.

Then each deviation larger than 2 mm. was counted. These were added to find the amplitude of action potentials per second in each period, then the two samples of rest and of work were added and averaged. Not enough cases were used to warrant further statistical treatment.

Part II. Data and results:

TABLE I

Comparison of averages of deflection during rest and work for squeezing a hand dynamometer in the left hand.

	Rest	Tension	After-Tension
Upper right arm	24.0	82.8	25.3
Lower right arm	30.1	140.8	26.1
Right hand	32.5	385.5	50.0
Right leg	24.5	334.5	33.0
Left foot	36.0	179.5	25.0
Mouth	48.5	330.0	16.0
Jaw	58.5	400.5	80.0
Nose	61.5	205.5	92.5
Ear	41.0	271.5	36.0
Chest	53.0	73.0	——
Abdomen	13.5	236.3	7.0
Neck	11.3	278.9	19.5

Most of the groups from which these measurements came consisted of from three to seven subjects. While these results were obtained under rigorous experimental conditions and the measurements accurately made to within .5 of 1 mm., they are shown here as indicative only of what might be expected from larger groups. The differences between the

TABLE II

Comparison of averages of deflection during rest and work for reading aloud.

	Rest	Tension	After-Tension
Left leg	20.9	28.9	25.4
Left thigh	35.5	42.5	35.0
Lower arms	37.3	45.5	34.8
Hands	57.5	73.7	57.5
Jaw	35.9	51.2	38.4
Chest	32.1	65.5	33.3

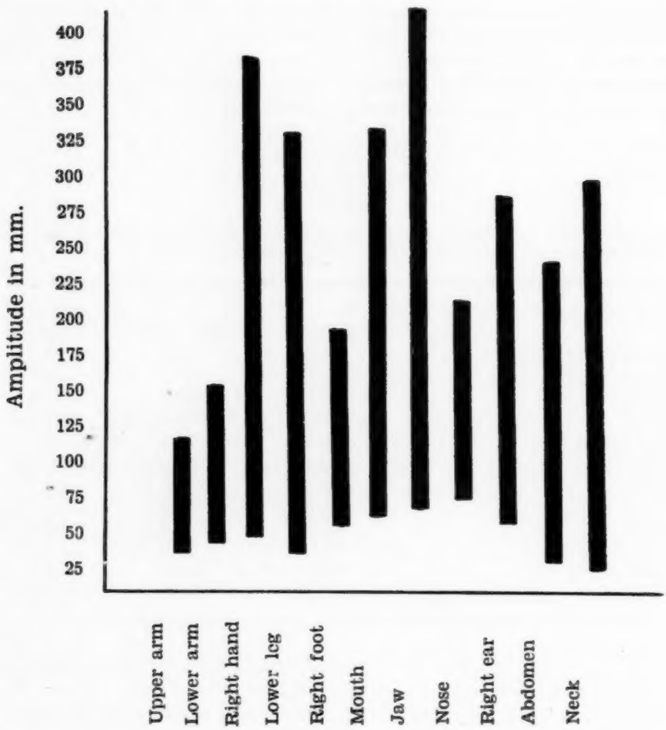

FIGURE I

A comparison of the amount of action potentials from the various parts of the body during the squeezing of a hand dynamometer. The columns arise from the level of rest.

averages of rest and tension are so great that a reliable difference is practically certain.

The great amount of tension for the nose and ear is very probably due to the closeness of these muscle groups to the larger ones of the jaw and tongue. In practically all the cases the lower arms and hands show a greater amount of activity than the upper arms. The same is true of the lower leg and foot.

Again, the figures shown in Tables I and II are to be considered as indicative only of what might be expected with

larger groups. It is difficult to say whether all the differences between rest and work are reliable, but the hands, jaws, and chest are apparently active.

The most significant thing appearing in the distribution of action potentials is the fact that they are not sharply localized. All parts of the body appear to be active, and there is evidence here to support the theory that the organism, when it acts, acts as a whole.

4. MUSCULAR ACTION POTENTIALS DURING IMPLICIT ACTIVITY

Part I. Apparatus, technique and procedure:

The apparatus used in this part of the experiment is essentially the same as that used in the first part. A detailed account of this apparatus has been given in a publication by R. C. Davis (4).

All subjects were taken from elementary classes in psychology. None of them had any particular training in experimental work.

A. Right arm: The subject was seated in the cage and the electrodes placed upon the right arm, one above and the other just below the elbow. Then he was given the following instructions: "Relax and try not to think of anything in particular. When the signal light flashes image squeezing a hand dynamometer in your right hand. Continue to image until the light comes on for the second time."

B. Left arm: Proceed as in "A."

C. Control. With the electrodes on the arm as in "B" the subjects were given the following instructions: "When the signal light comes on do not bother to think of anything."

D. Right leg: Proceed as in "A."

E. Left leg: Proceed as in "A."

F. Control. With the electrodes still on the leg proceed as in "C."

Not more than two measurements from each person could be secured at any one sitting. Action potentials were taken from the right or left arm and leg of each subject. As soon as the task was completed the subjects reported whether they were successful or unsuccessful.

A short strip of film was run of relaxation. Then the camera was started and the signal light flashed. After about 3 seconds of film had been run the camera was stopped and a ten-second pause introduced before starting it again, after which the second signal was given. Thus the subject

engaged in imaging some 15 or 20 seconds but only the first and last 3 or 4 seconds of this period were photographed.

The aim of this procedure was to get a rest period which was not separated from the work periods by any great amount of time. But it was found that subjects were often hard put to keep from "thinking" about what they were to do when informed beforehand of the nature of the task. On the whole it would have been better to secure a picture of relaxation and then to inform the subject of what he had to do. In this manner one would avoid getting any of the effects of thinking of the task beforehand in the rest period.

In measuring, the time line was marked off into half-second intervals which in turn were subdivided into 1/12 second intervals. The amplitude of the largest deviation in each 1/12 second was measured in fiftieths of an inch. These were added together for each ½ second period. Three such consecutive ½ second periods were added together and used as a measure of the amount of deflection during rest. Likewise, three consecutive ½ second periods beginning with the signal were used as a measure of the beginning and of the end of the total period of imaging.

The same procedure was carried out for typing, whistling and singing, and playing a wind-instrument except that no control was run.

The subjects were classified on the basis of their report according to whether they were successful or unsuccessful in imaging. It is to be noted, however, that there were many degrees of success reported. Some succeeded "fairly well"; some reported "Yes, I could imagine it"; while others reported they could imagine clearly. In many cases the hesitation to report upon success leads one to believe that there are many doubtful reports, reports given by subjects who were not sure whether they had or had not succeeded. Questioning such individuals brought forth the answer that they "guessed they were successful." There were some cases which indicated that the subject recalled an incident of the act which he was to image and did not really image performing the act. The following report illustrates the point: One subject, when asked if he succeeded, reported, "I thought of some of the fellows at the house the other night who were squeezing corks." In this case the subject did not do what he was instructed to do. There is probably a difference in the amount of deflection concerned with these different reactions.

A. Action potentials were secured from the right arm of

13 subjects (Table III) all but 2 of whom were men. It will be noticed that the increment begins within the first half-second after the stimulus has been presented and increases rapidly to the end of the first period of imaging. The difference between the first half-second of imaging and the rest period is not reliable but it rises to a fairly reliable figure by the end of the period. By the end of the second period of imaging this difference has reached a value that is statistically reliable. A real difference in the amount of deflection during rest and imaging exists.

If those subjects who were unable to image the tasks given them are taken out of the distribution, little change in reliability of the increments results. The amount of deflection for the second half-second and for the last period of imaging is appreciably greater.

We can conclude from these measurements that, during the imaging of squeezing a hand dynamometer in the right hand, the muscles of the right arm are more active than they are during rest. Removing the unsuccessful subjects from the distribution slightly increases the reliability of the difference between rest and work. These findings are in agreement with those of Jacobson (8-14).

B. Action potentials were secured from the left arms of 3 women and 12 men none of whom had had any experience in experimental work. The results (Table III) show a small increase in the amount of deflection during the first half-second of imaging. However, this increment fails to appear throughout the rest of the period. Consequently, the total increment for the first period is not reliable though there is suggested a tendency for this period to be more active than the rest period.

The difference between the second period of imaging and the rest period is also not reliable. However, there is a strong tendency for this period to be more active than that of rest.

When the 7 successful subjects, i.e., subjects who, by their report, indicated they were able to perform the task given them, are grouped together the difference in the amount of deflection between the rest period and the second period of imaging reaches a value which is fairly reliable (2.28). The tendency for more activity to occur in the first period of imaging is greater (1.34) than when all subjects are thrown together. The amount of activity shown in the first half-second is considerably lower.

Using the remaining 8 unsuccessful subjects to form a distribution we find no definite tendency. At the end of the

first period the critical ratio is .42; at the end of the second period .20. It is probable that, if all the doubtful reports could be eliminated from the successful group, real or significant differences between the periods of rest and imaging would show.

TABLE III

A comparison of the amount of deflection for rest with that for imaging. Action potentials from the right and left arms of 13 and 15 subjects respectively imaging squeezing a hand dynamometer in the right hand.

	Rest	1st Period of Imaging				2nd Per. Imaging
	1½ sec.	1st ½ sec.	2nd ½ sec.	3rd ½ sec.	Total Imaging	1½ sec.
Right arm						
Av.	34.73	38.00	47.10	49.10	44.75	55.08
Sigma	9.03	14.51	30.64	28.86	24.31	27.78
r		.80	.80	.71	.80	.63
Sigma (diff)		2.53	6.97	6.54	4.98	6.50
D. (rest and work)		3.27	12.37	14.37	10.02	20.35
D/Sigma (diff)		1.29	1.82	2.20	2.14	3.14
Left arm						
Av.	35.80	37.20	35.90	36.30	36.40	38.40
Sigma	7.14	5.82	7.28	6.99	6.43	8.75
r		.77	.44	.95	.96	.79
Sigma (diff)		1.19	.23	.62	.51	1.40
D. (rest and work)		1.40	.10	.50	.60	2.60
D/Sigma (diff)		1.18	.44	.81	1.18	1.85

From these results we can conclude that (1) successful subjects show a definite tendency to be more active in their left arm during the imaging of squeezing a hand dynamometer in the right hand than unsuccessful subjects; (2) this tendency approaches statistical reliability.

C. The control group (Table IV) gives an interesting group of figures to compare with those in Table III. Action potentials were taken from the left arms of 9 subjects, 3 men and 6 women instructed not to image. The test was run immediately after they had tried imaging. As seen in the table all differences are minus differences, which indicates that the longer these subjects sat the more relaxed they became.

Unsuccessful subjects do not show this decrement. They maintain their initial amount of activity, and, if anything, tend to increase it slightly.

The results of the control group lead us to conclude that (1) the increments found in the preceding tables are not a spurious effect of the light used as a stimulus, of the unique conditions under which the experiment was performed, nor

of the lapse of time; (2) that the observed increments are due to the subject's successful performance of the task given him.

D. In the distribution for Table V, showing action potentials in the right leg, 12 subjects were used. Two of these were women. The results show a very definite tendency for the right leg to be more active during the work period. As in some of the preceding results, when the unsuccessful subjects are weeded out, the difference values show a greater statistical reliability than when the successful and the unsuccessful are grouped together. At the end of the first period the critical ratio is then 2.68; while at the end of the second period the critical ratio is then 2.22. The increase in the amount of deflection is shown to take place rather quickly during the first 3 half-seconds of imaging. Just how soon after the stimulus the imaging begins is not shown but the increment for the first half-second indicates that the process has started within that short time. This time is, of course, measured from the beginning of the stimulus light. In concluding, the results show a strong tendency for the right leg to be more active during the time the individual engages in imaging than during rest. This tendency approaches statistical reliability.

TABLE IV

A comparison of the amount of deflection for rest with that for the periods in which no imaging took place, i.e., the control periods. Action potentials taken from the left arms and legs of 9 subjects, 3 men and 6 women.

	Rest	1st Period of Imaging				2nd Per. Imaging
Left arm	1½ sec.	1st ½ sec.	2nd ½ sec.	3rd ½ sec.	Total Imaging	1½ sec.
Av.	38.00	38.33	36.11	34.55	36.32	35.76
Sigma	7.60	4.67	3.61	4.18	3.96	5.19
r		.77	.44	.82	.72	.89
Sigma (diff)		1.70	2.28	1.60	1.84	.79
D. (rest and work)		.33	—1.89	—3.45	—1.68	—1.24
D/Sigma (diff)		.19	.83	2.16	.91	1.58
Left leg						
Av.	35.11	35.90	33.70	34.80	34.37	35.84
Sigma	3.84	5.01	2.82	4.96	4.90	5.46
r		.97	.95	.97	.97	.91
Sigma (diff)		.54	.50	.55	.52	.85
D. (rest and work)		.79	—1.41	—.31	—.74	.73
D/Sigma (diff)		1.47	2.82	.57	1.43	.86

TABLE V

A comparison of the amount of deflection for rest with that for imaging. Action potentials from the right and left legs of 12 and 13 subjects respectively imaging squeezing a hand dynamometer in the right hand.

	Rest	1st Period of Imaging				2nd Per. Imaging
Right leg	1½ sec.	1st ½ sec.	2nd ½ sec.	3rd ½ sec.	Total Imaging	1½ sec.
Av.	32.22	34.40	38.50	40.90	37.90	42.16
Sigma	.47	7.67	17.72	16.80	12.50	21.48
r		.75	.86	.81	,79	.76
Sigma (diff)		1.42	3.59	3.54	2.32	5.30
D. (rest and work)		2.20	6.30	8.70	5.70	9.96
D/Sigma (diff)		1.41	1.87	2.49	2.46	1.89
Left leg						
Av.	32.80	33.20	34.00	34.50	33.86	33.96
Sigma	5.75	4.99	7.50	9.12	5.98	5.73
r		.90	.71	.60	.70	.94
Sigma (diff)		.68	1.37	1.88	1.18	.50
D. (rest and work)		.40	1.20	1.70	1.06	1.16
D/Sigma (diff)		.59	.88	.90	.90	2.32

E. Thirteen untrained subjects, 2 of whom were women, were used in this section to test activity in the left leg (Table V). Not much activity appears in the first period of imaging (.90). There is, however, an indication that the leg tends to become more active with each successive half-second. By the end of the second period of imaging the difference in the amount of action potentials as compared to rest approaches a value which is fairly reliable (2.32).

When the successful subjects are used to form a distribution, the increase in activity throughout the first period is much greater (1.27). The last period of imaging does not show so much activity (1.81).

From these results we can conclude that (1) there is a small tendency for the left leg to be more active during imaging than during rest; (2) that this tendency is greater for successful subjects than for the unsuccessful ones.

F. The control group for the left leg (Table IV) consisted of 9 subjects, 3 men and 6 women. As in the case of the control group for the arm, most of the differences are minus values. Unlike the unsuccessful subjects, who tend to maintain their initial level of activity, the control group grew more quiet and relaxed as the period progressed. We can conclude that (1) subjects show a decrease in the amount of deflection when they are instructed not to engage in imag-

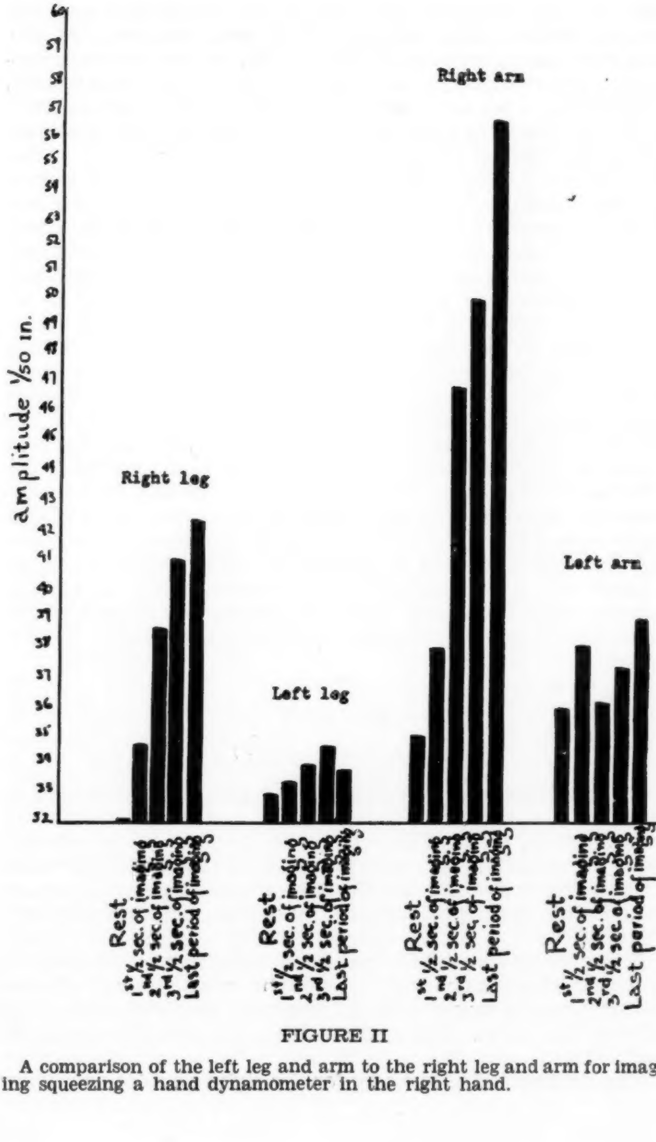

FIGURE II

A comparison of the left leg and arm to the right leg and arm for imaging squeezing a hand dynamometer in the right hand.

ing; (2) the stimulus light, the novel conditions, and the length of time used had no effect upon the results; (3) whatever increments there are, are due to the subject's successful or attempted performance of the task given to him.

In Figure II we see a comparison of the right arm and the right leg. There is a considerably smaller amount of deflection from the leg than from the arm. The amount of deflection for the left arm and leg is also shown. It is immediately apparent that both the left members are much less active. The right leg is considerably more active than the left arm. It will be noticed that the ratio for the right arm and leg is about the same as that for the left arm and leg.

The distribution of the activity in general seems to be somewhat unilateral in character with the center of greatest activity in the right arm. Now, while we can be certain that the increments of action potential are concomitant with imaging, we cannot definitely say that the peculiar character of the distribution of such activity is due to the fact that it was with the right hand that the imaging took place. It may be that a similar pattern would result if the left hand were used. However, should the distribution assume its present form but center on the left instead of the right side of the body there might be some grounds for saying that the clearness or success of the performance of an imaged act is concomitant with concentration of activity around some focal point and that diffusion or the absence of activity (action potentials) explains the failure to perform.

Section II

IMAGING TYPING

The subjects who form the present group consist of 4 men and 8 women, none of whom have had any special training in experimental work. Moreover, only two of these subjects were fair typists; the rest knew how to type a little or were just learning. From these 12 subjects action potentials were taken from the right arm of 7 and from the left arm of 5 (Table VI).

The general level of the right arm is below that of the left. However, this is apparently due to the small number of cases rather than to any actual difference in the level of activity of the two arms. The increments are about the same for both arms.

The first period of imaging for the right arm does not show

the growth of activity so well as the same period for the left arm. The differences between rest and the work periods are more reliable for the right than the left, but here again the effect of too few cases shows up.

When the action potentials from both arms are thrown together all difference values are statistically reliable. The critical ratio at the end of the first period is 4.15; that at the end of the last period 3.81.

We can conclude from the above results that (1) during the time subjects engage in imaging typing the alphabet there is an increase in action potentials in both arms; and that (2) these difference values are statistically reliable.

TABLE VI

A comparison of the amount of deflection for rest with that for imaging. Action potentials taken from the right and left arms of 7 and 5 subjects respectively imaging typing the alphabet.

	Rest	1st Period of Imaging				2nd Per. Imaging
	1½ sec.	1st ½ sec.	2nd ½ sec.	3rd ½ sec.	Total Imaging	1½ sec.
Right arm						
Av.	32.83	37.29	38.57	42.29	39.36	44.71
Sigma	2.92	6.73	6.97	11.70	7.20	11.68
r		.84	.48	.48	.69	.52
Sigma (diff)		1.72	2.32	4.01	2.10	3.95
D. (rest and work)		4.46	5.74	9.46	6.53	11.88
D/Sigma (diff)		2.59	2.08	2.36	3.11	3.01
Left arm						
Av.	42.04	49.60	53.60	50.00	51.06	53.30
Sigma	8.69	12.50	13.18	11.65	12.04	10.94
r		.72	.63	.84	.72	.42
Sigma (diff)		3.89	4.58	2.85	3.75	4.80
D. (rest and work)		7.56	11.56	7.96	9.02	11.26
D/Sigma (diff)		1.94	2.52	2.79	2.41	2.35

Action potentials taken from the right and left legs of 10 subjects, 3 of whom were men, during the time they engaged in imaging typing show no reliable increases. Neither is there any significant trend. There seems to be a small increase in action potentials during the first half-second of imaging but during other periods the amount drops below the level of rest.

This lack of action potentials in the legs may be due to the composition of the group. In the hand dynamometer tests only one or two women were used as subjects. In selecting subjects for the typing tests it was found few student men

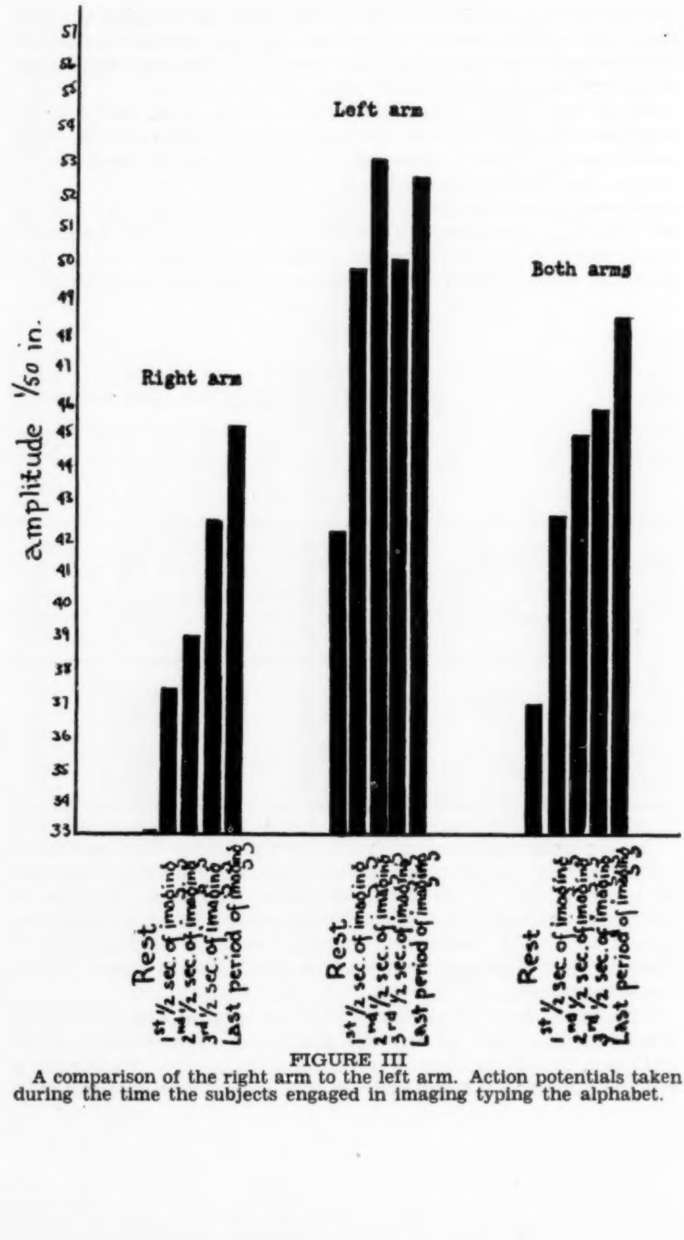

FIGURE III
A comparison of the right arm to the left arm. Action potentials taken during the time the subjects engaged in imaging typing the alphabet.

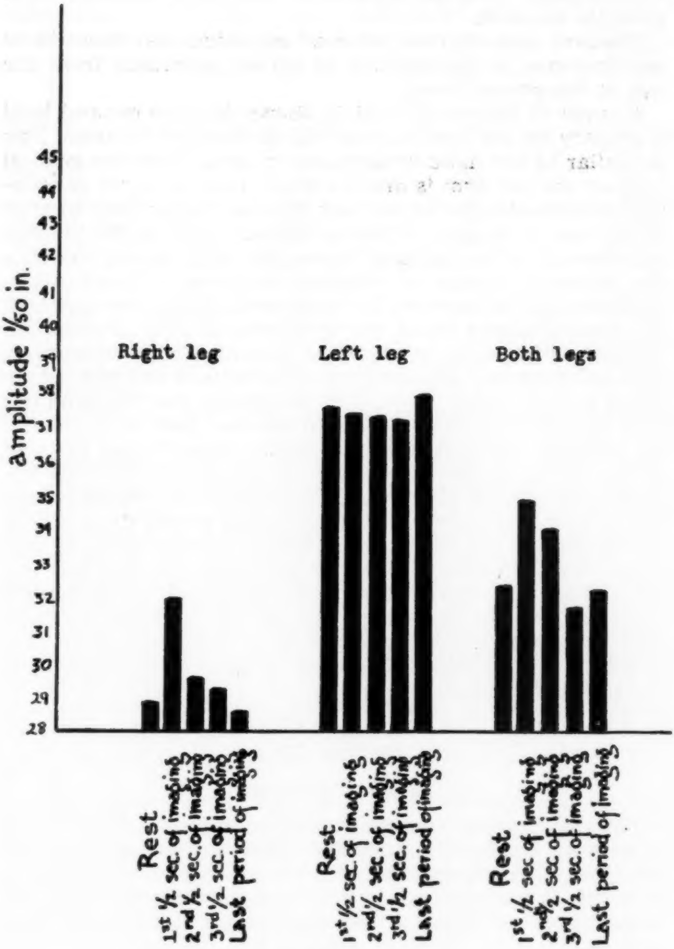

FIGURE IV

A comparison of the right leg to the left leg. Action potentials taken during the time the subjects engaged in imaging typing the alphabet.

could type. Consequently, there were more women in this group. In general it is difficult to secure action potentials from women perhaps because of the fatty tissues which underlie the skin.

However that may be, we must conclude that there is no real increase in the amount of action potentials from the legs in the present case.

A study of Figures III and IV shows that the general level of activity for the legs is not so high as that for the arms. This is similar to the hand dynamometer tests. That the general level of the left arm is much higher than the right is probably attributable to the number of cases rather than to anything else. In support of this is the fact that unlike the distribution of action potentials over the body during the time the subjects engage in imaging squeezing a hand dynamometer, the increments due to imaging typing the alphabet are approximately equal, not proportional. The distribution of action potentials, in so far as increments are concerned, does not show any unilaterality. The focus of activity is definitely in both arms. Any slight advantage the left hand has over the right may also be due to the fact that since most of the subjects were not very good typists, they did not get very far in typing before the periods were over. Usually the beginner must think where the next letter is, for, unless he has had practice in typing the alphabet, the letters do not form into patterns as do the letters of words. Consequently, he proceeds slowly, in many cases, covering only the first few letters. These first few letters from A to G fall under the left hand. The rise in the level of rest for the left hand is due in part, as has been said, to the number of cases, and in part possibly to the subject's inability to keep from thinking of the task beforehand.

Section III

IMAGING SINGING

The group for the singing tests was composed of 3 men and 9 women. Table VIII indicates that a tendency for the muscles of both arms to be active is present. This tendency, however, is not strong. As previously stated, the difficulty encountered is that of securing action potentials from women.

As in the case of typing all subjects reported success. In some of the earlier tests where the composition of the groups was mostly male more unsuccessful attempts were reported.

TABLE VII

A comparison of the amount of deflection for rest with that for imaging. Action potentials taken from the right and left legs of 10 and 4 subjects respectively imaging typing the alphabet.

	Rest	1st Period of Imaging				2nd Per. Imaging
Right leg	1½ sec.	1st ½ sec.	2nd ½ sec.	3rd ½ sec.	Total Imaging	1½ sec.
Av.	28.80	31.83	29.50	29.33	30.20	28.27
Sigma	5.23	6.98	5.03	5.84	5.63	5.85
r		.83	.74	.74	.74	.83
Sigma (diff)		1.24	1.18	1.29	1.26	1.35
D. (rest and work)		3.03	.70	.53	1.40	—.53
D/Sigma (diff)		2.44	.59	.41	1.11	.39
Left leg						
Av.	37.45				37.12	37.95
Sigma	2.25				2.36	2.84
r					.63	.81
Sigma (diff)					1.00	.83
D. (rest and work)					—.32	.50
D/Sigma (diff)					.32	.60

The question arises here whether men do not report their doubtful and unsuccessful attempts more readily than do women. There is some evidence that they do since their reports correlate better with the amount of deflection secured during the time they engaged in imaging than the reports of the women correlate with their records. When the unsuccessful subjects were weeded out the difference values became more reliable, and were it possible to weed out such cases from the present group the differences would probably be significant.

In concluding we can say that there tends to be an increase in action potentials from the arms during the time subjects engage in imaging singing. The tendency is only moderately strong.

A comparison of the right arm to the left arm and the figure resulting from the combination of the two (Fig. V) indicates that the amount of deflection varies a great deal from period to period and that no steady or progressive trend is shown.

This variability may be due to the nature of the stimulus, there being less activity in some parts of the song the subjects had to image singing. Again, some of this variation is undoubtedly due to the smallness of the group used. That there is a tendency toward greater activity in the work pe-

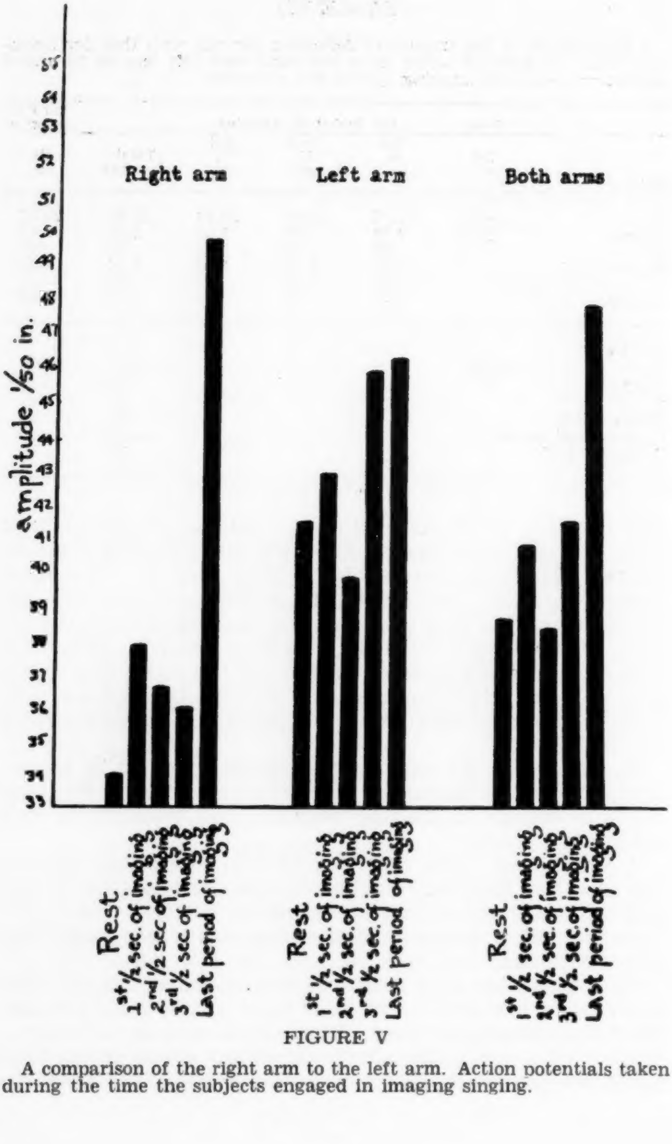

FIGURE V

A comparison of the right arm to the left arm. Action potentials taken during the time the subjects engaged in imaging singing.

riods shows clearly.* Especially is this true of the last period of imaging.

From a study of Table IX we find no increase in action potentials from the legs. The differences are, in general, very small, and no tendency is indicated. As in the case of typing we must conclude that there is no increase in action potentials from the legs during the time the subjects engage in imaging singing in the present case. There are reasons for doubting their complete absence owing to the composition of the group tested, its size and the length of time the subject sat.

TABLE VIII

A comparison of the amount of deflection for rest with that for imaging. Action potentials taken from the right and left arms of 5 and 7 subjects respectively imaging singing the popular song "Dinah."

	Rest	1st Period of Imaging				2nd Per. Imaging
	1½ sec.	1st ½ sec.	2nd ½ sec.	3rd ½ sec.	Total Imaging	1½ sec.
Right arm						
Av.	33.94	37.60	36.40	36.00	36.12	49.96
Sigma	2.11	5.68	2.43	2.61	3.08	24.19
r		.31	.43	—.70	.31	—.80
Sigma (diff)		2.42	1.10	.85	1.41	10.11
D. (rest and work)		3.66	2.46	2.06	2.18	16.02
D/Sigma (diff)		1.51	2.23	2.43	1.54	1.58
Left arm						
Av.	41.44	42.85	39.71	45.71	42.73	46.27
Sigma	4.62	3.76	3.50	9.73	3.71	13.88
r		.79	.83	.21	.59	.17
Sigma (diff)		1.06	.97	3.72	1.46	5.24
D. (rest and work)		1.41	—1.73	4.72	1.29	4.83
D/Sigma (diff)		1.33	1.77	1.15	.88	.92

Section IV

IMAGING PLAYING A WIND INSTRUMENT

Action potentials from the left arms and legs of 4 and 5 subjects respectively were secured during the time they engaged in imaging playing a clarinet (Table X). They show a small increase over rest. Owing to the smallness of the group nothing very definite can be said. It should be pointed out that all members of these groups were men and that the increase in action potentials from the leg is about equal to that of the arm.

All that can be said in concluding is that there seems to be a tendency for an increase in action potentials during the time subjects engage in imaging playing a wind instrument to occur in both the left arm and leg. This tendency is only moderately strong.

TABLE IX

A comparison of the amount of deflection for rest with that for imaging. Action potentials taken from the right and left legs of 8 and 5 subjects respectively imaging singing the popular song "Dinah."

	Rest	1st Period of Imaging				2nd Per. Imaging
Right and Left legs	1½ sec.	1st ½ sec.	2nd ½ sec.	3rd ½ sec.	Total Imaging	1½ sec.
Av.	37.98	41.12	37.25	35.50	37.95	37.68
Sigma	6.09	5.32	5.29	7.19	5.04	5.88
r		.74	.74	.73	.89	.86
Sigma (diff)		1.48	1.48	1.77	1.00	1.11
D. (rest and work)		3.14	—.73	—2.48	—.04	—.30
D/Sigma (diff)		2.12	.49	1.40	.40	.27
Left leg						
Av.	41.44				40.79	41.16
Sigma	3.40				2.20	3.87
r					.62	.60
Sigma (diff)					1.19	1.47
D. (rest and work)					—.65	—.28
D/Sigma (diff)					.55	.19

TABLE X

A comparison of the amount of deflection for rest with that for imaging. Action potentials taken from the left arms and legs of 5 and 4 subjects respectively imaging playing "Dinah" on the clarinet.

	Rest	1st Period of Imaging				2nd Per. Imaging
Left arm	1½ sec.	1st ½ sec.	2nd ½ sec.	3rd ½ sec.	Total Imaging	1½ sec.
Av.	35.72				35.02	63.44
Sigma	2.90				2.48	34.34
r					.42	.70
Sigma (diff)					1.31	14.25
D. (rest and work)					—.70	27.72
D/Sigma (diff)					.53	1.92
Left leg						
Av.	36.74				39.38	68.80
Sigma	3.39				2.68	33.44
r					.27	.27
Sigma (diff)					1.85	16.34
D. (rest and work)					2.64	32.06
D/Sigma (diff)					1.43	1.96

CONCLUSIONS

In conclusion there appears to be an increase in muscular action potentials from nearly all of the muscle groups tested during the imaging of the various tasks. There is no good evidence of localization to the muscle groups commonly thought to be involved in such performances. While such action potentials seem to be necessarily concomitant as shown by the report of the unsuccessful subjects and the control groups they are not localized in any particular part of the body nor are they exclusively peculiar to imaging since other workers have shown that action potentials accompany other implicit activities also. The distribution of these action potentials seems to indicate that during the revival of vestigial responses one can expect to be present any muscular activity that accompanied the original response.

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